

Transmission of Infectious Diseases During Commercial Air Travel

**Testimony of
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Chairman Mica and Members of the Subcommittee, I am Mark Gendreau, and I am an attending physician at Lahey Clinic Medical Center, a tertiary care teaching hospital located in the greater Boston region. One of my clinical and research interests over the past 5 years has been health issues related to commercial air travel. Recently, a colleague and I published a comprehensive analysis on the current knowledge and status of Infectious Disease Transmission during Commercial Air Travel. This publication represented a year and a half effort of reviewing and analyzing all available scientific and governmental literature concerning infectious disease spread aboard aircraft. My testimony will summarize the findings of our analysis.

Joshua Lederberg, a Nobel laureate once wrote “The microbe that felled one child in a distant continent yesterday can reach yours today, and seed a global pandemic tomorrow. With over one billion passengers traveling by air annually the risk of disease transmission during commercial air travel and the potential of commercial aircraft serving as vehicles of pandemics is clearly present and has recently gained increased interest. Over the past decade the world community has been introduced to many new and reemerging infectious diseases. Diseases such as Severe Acute Respiratory Syndrome, Avian influenza (H5N1), West Nile fever, Monkey pox have emerged or resurged. The anthrax outbreak of 2001 demonstrated the ever present threat of bioterrorism. Fortunately, the widespread general perception that transmission of infection between aircraft cabin occupants and facilitated by the nature of the aircraft cabin environment is unfounded. In fact, the current environmental control systems utilized on modern commercial aircraft, when properly functioning, limit the spread of disease within the cabin.

Since 1946, there have been a number of reported outbreaks of serious infectious diseases aboard commercial airlines. These include: influenza, measles, SARS, Tuberculosis, food poisoning, and small pox. While less serious outbreaks like the common cold or simple viral syndromes have not been reported, common sense suggests that they likely occur and lack of reporting is likely attributable to the difficulties of investigating such outbreaks in view of the ubiquitous nature of these minor infections.

Fresh in everyone’s minds is the Severe Acute Respiratory Syndrome (SARS) outbreak of 2002-2003. As the first severe contagious disease of the twenty-first century, SARS exemplifies the ever-present threat of new emerging infectious diseases and the real potential for rapid dissemination made possible by the current volume and speed of air travel. A total of 40 commercial air flights have been investigated for carrying SARS-infected passengers. Five of these flights have been associated with probable on-board transmission of SARS inflicting a total of 37 passengers.

One three-hour flight (Air China flight 112), a 737-300 aircraft, carrying 120 passengers and traveling from Hong Kong to Beijing on March 15, 2003 constituted a superprevalence event accounting for 22 of the 37 air travel-SARS cases. The number of secondary cases from Flight 112 remains under investigation but may have involved over 300 persons.

The spread of microorganisms to humans occurs by one of four mechanisms: contact/large droplet, airborne, common vehicle and vectorborne. With the purpose of not being overwhelming, suffice it to say that although all modes are relevant to commercial air travel, large droplet and airborne mechanisms likely represent the greatest risk for passengers within the aircraft given the high density and close proximity of passengers. Large droplet transmission is considered a form of contact transmission and involves the generation of large droplets (> 5 microns) contaminated with microorganisms by an infected person via sneezing, coughing or talking. These droplets are propelled short distances (< 3 feet) and either deposited on a susceptible host's conjunctiva or mucosa or onto an inanimate object such as a table, chair or door knob. This mode of transmission is seen in, upper respiratory tract viral infections, the common cold, influenza, meningococcus and anthrax. Airborne transmission on the other hand involves aerolization of an infectious agent through droplet nuclei (residua of large droplets containing microorganisms that have evaporated to size less than 5 microns). These tiny nuclei are not propelled through the air like large droplets but rather become aerosolized and disperse widely depending upon environmental conditions where they remain suspended in air for indefinite periods. Influenza, SARS, measles, tuberculosis, legionnaires and small pox are examples of airborne infectious diseases.

What is the risk of contracting an infectious illness during commercial air travel? The risk within the confined space of a commercial aircraft cabin is difficult to determine. In general in addition to proximity, successful dissemination of an infectious disease within an enclosed space to other hosts is dependent upon multiple factors including: chance, mode of transmission, infectiousness of the source, pathogenicity of the microorganism, proximity to source, duration of exposure, environmental conditions (ventilation, humidity, and temperature) and host-specific factors such as general health and immune status. How these factors influence risk of disease transmission within the aircraft cabin remains unclear.

Insufficient data prohibits a proper analysis to gain an idea of the probability of disease transmission. Many of the epidemiological studies that are available are compromised by reporting bias due to incomplete or inaccurate passenger manifests during the time of the study further complicating the issue of risk assessment. Despite these limitations available data suggests that the risk of transmission to other symptom-free passengers within the aircraft cabin is associated to sitting within two rows of the affected passenger (proximity) with a flight time greater than 8 hours (duration). This risk was derived from epidemiological investigations in the 1990s by the Centers of Disease Control and Prevention (CDC) regarding in-flight tuberculosis transmission, and has been assumed to be relevant to other infectious diseases. However, some variation in this association has been reported. For example, the largest in-flight SARS outbreak (Air China Flight 112) in which passengers seated as far as seven rows were affected and the flight time was only three hours. This dissemination pattern may be important in that it did not follow the typical example of in-flight transmission of airborne pathogens-namely flight time greater than 8 hours and sitting within 2 rows of the source passenger. The duration of flight 112 was 3 hours and affected passengers were seated 7 rows in front and 5 rows behind the index passenger. This different time and distribution pattern of transmission signifies the urgent need to study airborne transmission patterns aboard commercial aircraft.

Risk of infection within the aircraft cabin also seems to be affected by ventilation within the aircraft. Ventilation dilutes the concentration of infectious particles within any confined space thereby reducing the probability of infection. Experience shows us that transmission becomes widespread within the passenger cabin involving all sections when the ventilation system is non operational as evidenced by an influenza outbreak involving passengers being kept aboard grounded aircraft with inoperative ventilation system.

Air circulation patterns aboard standard commercial aircraft are side-to-side (laminar) with air entering the cabin from the overhead, circulating across the aircraft and exiting the cabin near the floor. Little to none front-to -back (longitudinal) airflow takes place. This air circulation pattern “compartmentalizes” the air flow into sections within the cabin; thereby limiting the spread of airborne particles throughout the passenger cabin. Ventilation capacity varies substantially, dependent upon the aircraft type, but typically averages 10 cubic feet per minute with normal cabin air exchanges ranging from 15 to 20 air changes per hour compared with 12 per hour for a typical office building. Ventilation can involve either 100 % fresh air in which outside air enters and leaves the cabin in a single pass or a system in which various fractions of air are recirculated from the aircraft cabin and mixed with fresh air. Most commercial aircraft in service recirculate 50 % of the air delivered to the passenger cabin for improved control of cabin circulation, humidity and fuel efficiency. This recirculated air usually passes through high efficiency particulate filters (HEPA) before delivery into the cabin.

In general, proper ventilation within any confined space decreases the concentration of airborne organisms in a logarithmic fashion with one air exchange removing 63 % of airborne organisms suspended in that particular space. In the case of recirculated systems, this relationship holds only if the recirculated air undergoes filtration through high efficiency particulate filters (HEPA). Most HEPA filters utilized on commercial airlines have a particle removing efficiency of 99-97 % at 0.3 microns this cutoff removes dust, vapors, bacterium and fungi. HEPA filters are also effective in capturing viral particles since they tend to disseminate by droplet nuclei.

HEPA filtering of recirculated cabin air as a means of minimizing the exposure of infectious particles is established within the scientific literature and is strongly endorsed by the medical community and cabin health experts. Currently the FAA and its British (Civil Aviation Authority) and European (Joint Aviation Authority) counterparts do not require the use of these filters on commercial airlines. Although it has been stated that HEPA filtration of recirculated cabin air is an industrial standard, a recent GAO survey of major U.S. air carriers found that 15 percent of large commercial aircraft that recirculate cabin air and carrying more than 100 passengers did not use HEPA filters. This number was larger in smaller regional commercial fleet and approached fifty percent.

Risk assessment incorporating epidemiological data into mathematical models may provide some insight into how proximity and ventilation influences disease transmission aboard commercial airlines. For instance, deterministic modeling utilizing data from an in-flight tuberculosis investigation revealed that doubling ventilation rate within the cabin reduced infection risk by half. Clearly ventilation provides a critical determinant of risk and efforts to increase ventilation may provide opportunities to reduce risk of infection.

Efforts leading to improved international regulations regarding the certification, inspection and maintenance of aircraft environmental control systems are needed. To minimize the risk of disease spread by aircraft, regulations requiring HEPA filters for any aircraft that utilizes recirculated air should be seriously considered.

Prevention of a disease outbreak is the most important means of control and requires a proactive approach. The government, aviation industry and medical community should better educate the general public on health issues related to air travel and infection control. The only way to eliminate any risk of cross-infection in the aircraft cabin and the rapid world-wide spread of an infectious agent, is to prevent intending passengers who are either substantially exposed to or carrying transmissible infections from flying. This needs to come from education and promoting individual responsibility since the systematic screening of passengers for contagious diseases is impractical. Although thermal scanners used in airports may be useful in detecting symptomatic travelers, they are not an effective means of control since persons exposed to an infectious disease could travel without any signs or symptoms yet still be infectious. Good hand hygiene and cough etiquette have been proven to reduce the risk of disease transmission and should be promoted. In March 2003, the WHO issued specific infection control guidelines for air travel and SARS (<http://www.who.int/csr/sars/travel/airtravel/en/index.html>). These guidelines are essentially an adaptation of universally accepted standard and droplet precautions; and include preflight exit screening and travel restrictions at regions with recent local transmission of SARS. These protocols should be reviewed by appropriate agencies and expanded to pertain to other infectious agents.

Passenger notification is also an issue that requires review. Although the CDC and WHO have published guidelines regarding flight crew and passenger notification after an in-flight exposure, notification is typically limited to flights longer than 8 hr and in some cases, dependent upon the design of the aircraft, to passengers seated only in the same cabin area. Public health officials have access to passenger manifests but historically these lists have been frequently incomplete, inaccurate or unavailable making it difficult to locate potentially exposed passengers in a timely fashion. This issue is being addressed by the CDC and Aerospace Medical Association and measures to improve the archiving of passenger manifests should be encouraged.

In summary, commercial aircraft are a suitable environment for the spread of pathogens carried by its occupants. The environmental control systems utilized in commercial aircraft seem to restrict the spread of airborne pathogens. Transmission of infectious diseases probably happens more frequently than reported for various reasons, including reporting bias and the fact that most diseases have a longer incubation period than air travel. Many important questions regarding the behavior of infectious agents within the aircraft cabin environment remain unstudied. For example, what factors affect the transmission of infectious diseases within the aircraft cabin? How effective are the ventilation systems used within the commercial aircraft with regard to emerging infections? Further assessment of risk through mathematical modeling is needed and will provide insight into disease transmission within the aircraft as well as control of outbreaks of different diseases. Use of HEPA filtration in aircraft utilizing recirculating systems needs to be addressed now if we are to be serious about minimizing disease spread within the aircraft cabin and improving the health of air travelers and flight crew. Finally, the International Health Regulations adopted worldwide in 1969 to limit the international spread of disease are being revised to provide a means for immediate notification of all disease outbreaks of international importance and are scheduled for final voting by the WHO general assembly in May 2005.

Outbreaks will be characterized by clinical syndrome rather than specific diagnosis to expedite reporting. These new regulations and continued vigilance by countries, health authorities, airlines and passengers will keep to a minimum but not eliminate the risk of disease spread by aircraft. The aviation industry, government and medical community should educate the general public on health issues related to air travel and infection control. Chairman Mica this concludes my testimony thank you for allowing me to participate in this hearing.

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